BIOLOGICAL STUDIES ON SUDANESE INLAND FISHES

II. Tilapia Nilotica Linnaeus

BY

M. A. Mahdi, S. Z. Rafail and A. A. Al-Kholy

INTRODUCTION AND METHOD

The reader is referred to Al-Kholy, Rafail and Mahdi (1973). Studies herein were carried out on *Tilopia nilotica.*

Length Distribution

Sandon (1950) stated that *Tilapia nilotica* might attain a maximum length of 400 mm or more. In these studies *Tilapia* of 550 mm in length were investigated. Studies herein were carried out on specimens of length ranging from 260 - 460 mm. Length frequencies shown in Table 1 were obtained.

TABLE 1.– LENGTH FREQUENCY OF *Tilapia nilotica*

Length in mm.	Frequency
260	103
280	134
300	29
320	246
340	17
360	156
380	68
400	66
420	27
440	13
460	10

The length frequencies shown in Table 1 were obtained from Table 3 after smoothing by combining length intervals. The length distribution is shown in figure 1 which has 3 modes at 280, 320 and 360 mm. These modes probably represent age groups X, X, + 1 and X + 2 respectively.

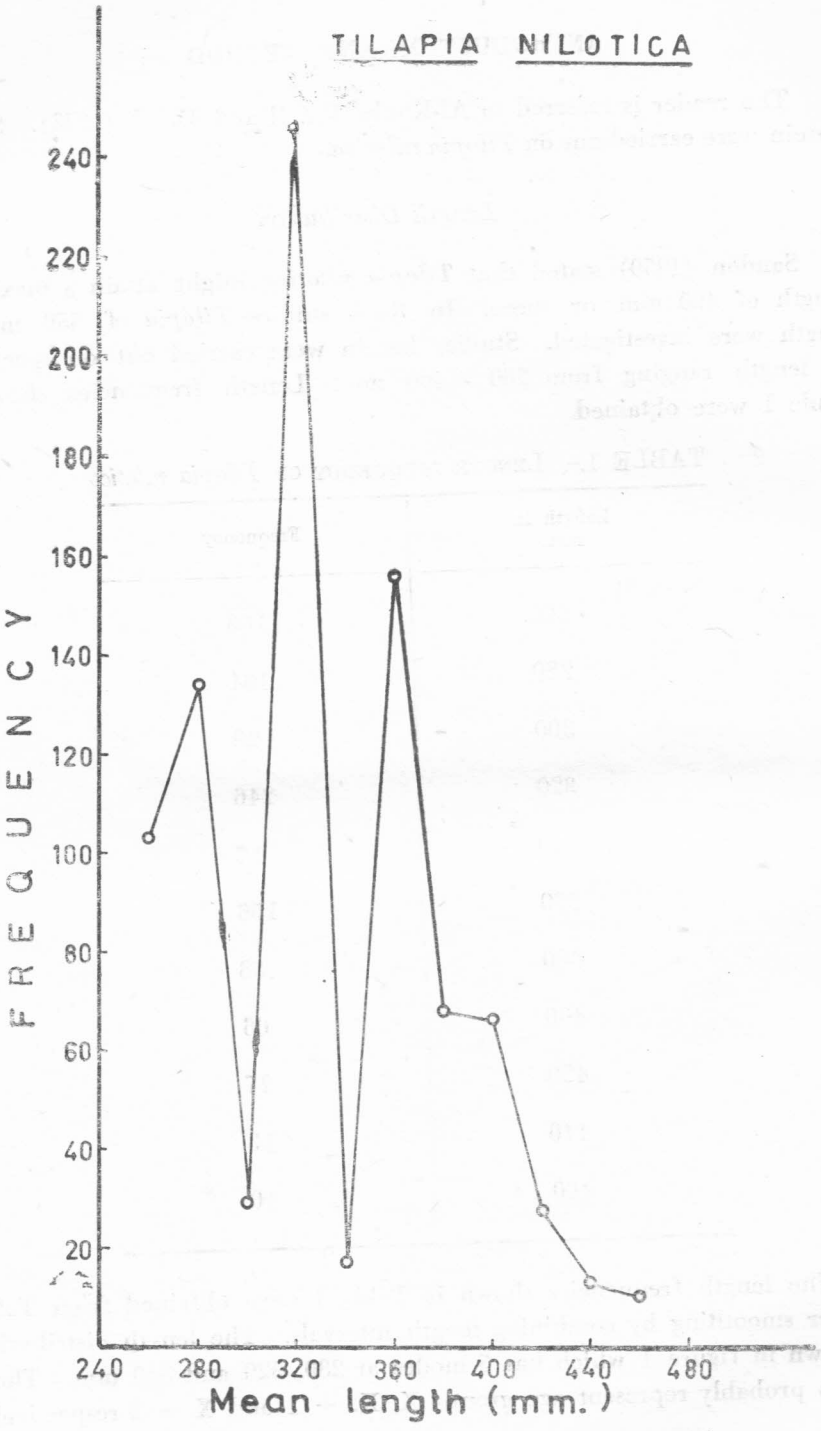


Fig. 1 : Length distribution of Tilapia nilotica

Thus growth of *Tilapia nilotica* is shown as follows :

Age in years	×	× + 1	× + 2
Fish length in mm	280	320	360

From scale readings age group X was found to be equivalent to age group II (see chapter on age length key). Thus age group I was missing in these studies.

Instantaneous total morality

The length frequency at which *Tilapia nilotica* becomes fully represented (f) was 320 mm. as shown in Table 2.

TABLE 2.—LENGTH FREQUENCY AND *Log frequency of Tilapia nilotica*

Length in mm.	frequency	Log frequency
320	246	2.3909
340	17	1.2304
360	156	2.1931
380	68	1.8325
400	66	1.8195
420	27	1.4314
440	13	1.1139
460	10	1.0000

When log frequency was plotted against length (Fig 2) i′ was equivalent to — 0.00957.

$$i' = -0{\cdot}00957$$

$$K = \frac{360 - 280}{4 - 2} = \frac{80}{2} = 40$$

$$i = -2.303 \times 40 \times -0.00957 \approx 0.88$$

$$\therefore \quad S \approx 0.415$$

i.e. about 42% of *Tilapia nilotica* survive per year after 3 years old.

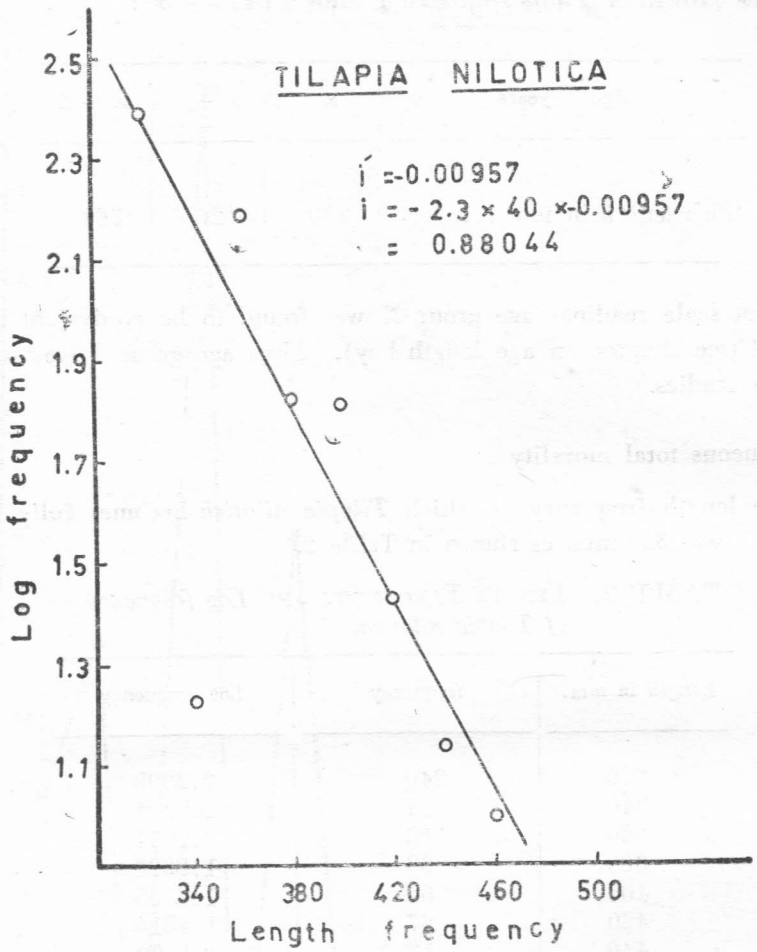


Fig. 3 ; log frequency against length of *Tilapia nilstca*

II Age Distribution

a. Length-Weight nelationship.

The length weight relationship of *Tilapia nilotica was* evaluated from the investigation of 869 specimens. The length ranged from 255 to 455 mm and their length distribution is shown in Table 3.

The specimens varied in weight from about 446 gms to about 3080 gms. The scatter diagram between log W against log L showed that there is a single equation for the length range studied (Fig. 3).

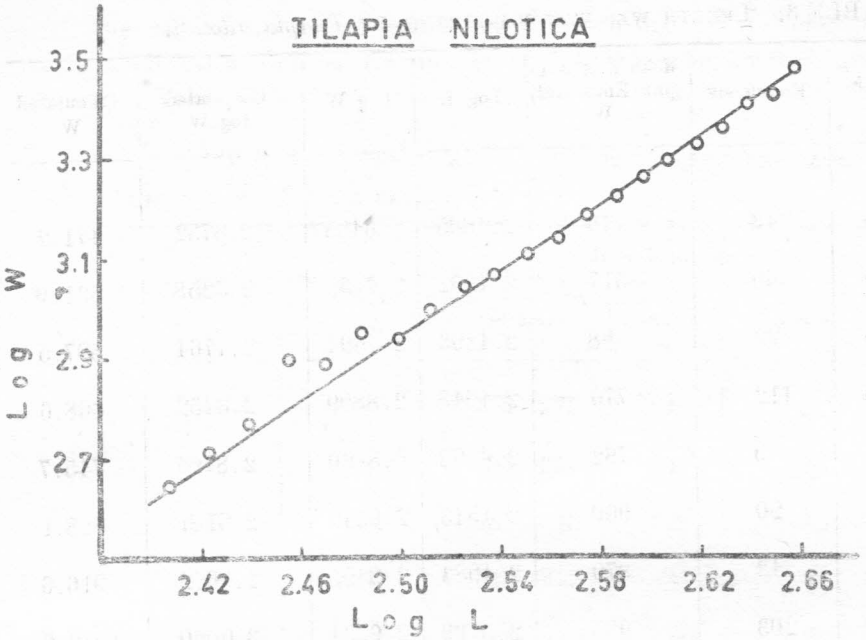


Fig. 2 log frequency against length of *Tilapia nilstca*

The equation of the straight line fitted by the least square method is as follows :

Length range	Equation
255—455	$\log W = -4.9032 + 3.1483 \log L$ $W = 1.249 \times 10^{-5} L^{3 \cdot 1483}$

The calculated log W values as well as W values are shown in Table 3.

b. Age-length key

Seventy three specimens of *Tilapia nilotica* belonging to five age groups were studied. Their length ranged from 175 - 455 mm. Age group I ranged from 175 - 275 mm with a mode at 255 mm. Age group II ranged from 255 - 325 mm with a mode at 265 mm. Age group III from 285 - 345 mm with a mode at 345 mm; age group IV, 345 - 415 mm with a mode at 365 mm; age group V, 425 - 455 mm with a mode at 425 mm.

TABLE 3.—LENGTH WEIGHT RELATIONSHIP OF *Tilapia nilotica*.

Length in mm L	Frequency	Mean weight in gms (Empirical) W	Log L	Log W	Caclulated log W	Calculated W
255	43	446	2.4065	2.6493	2.6732	471.2
265	60	517	2.4232	2.7132	2.7258	531.9
275	22	588	2.4393	2.7694	2.7764	597.5
285	112	776	2.4548	2.8899	2.8252	668.6
295	9	762	2.4698	2.8820	2.8725	745.7
305	20	900	2.4843	2.9542	2.9181	828.1
315	43	870	2.4983	2.9395	2.9622	916.6
325	203	985	2.5119	2.9934	3.0050	1012.0
335	10	1120	2.5250	3.0492	3.0462	1113.0
345	7	1180	2.5378	3.0719	3.0865	1220.0
355	150	1295	2.5502	3.1123	3.1256	1336.0
365	6	1410	2.5623	3.1492	3.1637	1457.0
375	30	1560	2.5740	3.1931	3.2005	1587.0
385	38	1710	2.5855	3.2330	3.2367	1725.0
395	50	1860	2.5966	3.2695	3.2717	1869.0
405	16	2000	2.6075	3.3010	3.3060	2023.0
415	24	2170	2.6180	3.3365	3.3390	2183.0
425	3	2340	2.6284	3.3692	3.3718	2354.0
435	1	2600	2.6385	3.4150	3.4036	2533.0
445	12	2690	2.6484	3.4298	3.4347	2720.0
455	10	3080	2.6580	3.4886	3.4650	2917.0

The ranges and mean lengths of different age groups (according to scale readings) as well as the number of fish belonging to each group are shown in Table 4.

TABLE 4.—LENGTH RANGES OF THE DIFFERENT AGE GROUPS OF *Tilapia nilotica*.

Age group	Number	Length in mm		
		Intervals	Mean	Increment
I	7	175—275	244	—
II	20	255—325	277	33
III	29	285—345	322	45
IV	12	545—415	367	45
V	5	425—455	437	70
Total . . .	73			

The growth estimated from length distribution curves were as follows :

Age in Years	X	X + 1	X + 2
Fish length in mm	280	320	360

Age group X corresponds to age group II as shown from scale readings i.e. age group I was missing from the length distribution investigations. The growth estimated from length distribution is then as follows :

Age in years	2	3	4
Fish length in mm	280	320	360

Thus, it is clear that estimates from length distribution agree with those from scale readings.

The length distribution of the different age groups as well as the age length key *Tilapia nilotica* is shown on Table 5.

TABLE 5.—AGE LENGTH KEY OF *Tilapia nilotica*

Length in mm	Number and percentage of fish belonging to age groups										Total No.
	I		II		III		IV		V		
	No.	%	Noü	%	No.	%	No.	%	No.	%	
175	1	100.0									1
185	0	100.0									0
195	0	100.0									0
205	0	100.0									0
215	0	100.0									0
225	0	100.0									0
235	1	100 0									1
245	1	100.0									1
255	2	40.0	3	60.0							5
265	1	14.3	6	85.7							7
275	1	20.0	4	80.0							5
285			3	75.0	1	25.0					4
295			2	40.0	3	60.0					5
305			1	16.7	5	83.3					6
315			0	0.0	4	100.0					4
325			1	20.0	4	80.0					5
335					5	100.0					5
345					7	77.8	2	22.2			9
355							2	100.0			2
365							5	100.0			5
375							1	100.0			1
385							1	100.0			1
395							0	100.0			0
405							0	100.0			0
415							1	100.0			1
425									2	100.0	2
435									1	100.0	1
445									1	100.0	1
455									1	100.0	1
Total .	7		20		29		12		5		73

The age length key (Table 5) shows that fish from 175 - 245 mm belong totally to age group I. From 255 - 275 mm age group I are mixed with age group II so that at length 255 mm, 40% of the fish belong to age group I and 60% belong to age group II. At 265 mm. 14.3% belong to age group I and 85.7% belong to age group II. At 275 mm, 20% belong to age group I and 80% belong to age group II.

From 285 - 325 mm age group II and III are mixed together with percentages shown in the table. At 335 mm all fish belong to age group III. At 345 mm, there were mixtures of age group III and IV so that age group III formed 77.80. From 355 - 415 mm all fish belonged to age group IV. From 425 - 455 mm there were only fishes belonging to age group V.

C — Growth rates

The two estimates of growth of *Tilapia nilotica* are shown in Table 6.

TABLE 6. — Growth estimetes of *Tilapia nilotica*.

Age	Growth estimated by		Accepted estimates mm.	weight in gms
	Lenwth frequeney mm.	Scale readings mm.		
1	—	244	244	410
2	280	277	280	633
3	320	322	320	964
4	360	367	360	1397
5	—	437	437	2569

The accepted growth of age 1 was considered as the estimate given by the scale reading, as the estimates from length frequency were missing. So long as both estimates gave almost the same values for ages 2, 3 and 4; minor differences may be due to errors in measurements or errors in grouping the different ages.

d — Age distribution

The scales of 73 specimens of *Tilapia nilotica* were studied. These were found to belong to age groups I - V. Studies on lengths were carried out on 869 specimens. When considering investigations on lengths and scales

as was previously mentioned, the number of fish assigned to each age group is shown on Table 7. In this table, at 255 mm, about 17 fish were found to belong to age group I, and about 25 fish belong to age group II. At 275 mm a reduction in number of fish was observed in both age groups I and II to about 4 and 17 fish respectively. At 325 mm there were about 40 fish belonging to age group II and 162 individuals assigned to age group III. Fish ranging from 355 - 415 mm and from 425 - 455 mm were all assigned to age groups IV and V respectively.

Summing up the number of fish belonging to the age groups I - V we get the following age distribution :

Age group	I	II	III	IV	V	Total
Frequency	31	225	271	316	26	869
Ratio	3.6	25.9	31.2	36.3	3.0	100

Table 7 shows the relation between the age groups in number. From the corresponding weights shown in Table 7 lesgth frequency is transformed to weight frequency from which the total weight of each age group was calculated. This is shown as follows :

Age group	I	II	III	IV	V	Total
weight in gms . . .	15308	152679	258057	502464	71405	999913
gms. weight per kilogram	15.3	152.7	258.1	502.5	71.4	1000

From the above total the ratio of the weight of age groups I, II, III, IV and V was equivalent to 15.3, 152.7, 258.1, 502.5 and 71.4 respectively. This means that in every kilogram weight of the catch of *Tilapia nilotica* there were about 15.3, 152.7, 258.1, 502.5 and 71.4 gms of age groups I, II, III, IV and V respectively.

TABLE 7.—AGE DISTRIBUTIN OF *Tilapia nilotica* SHOWING THE RELATION BETWEEN THE AGE GROUPS IN NUMBER AND WEIGHT, WHEN THE CALCULATED WEIGHT IS USED.

Lenght in mm	Number	Weight	Number of fish in age group				
			I	II	III	IV	V
255	43	471.2	17.2	25.8			
265	60	531.9	8.6	51.4			
275	22	597.5	4.4	17.6			
285	112	668.6		84.0	28.0		
295	9	745.6		3.6	5.4		
305	20	828.1		3.3	16.7		
315	43	916.6		0.0	43.0		
325	203	1012.0		40.6	162.4		
335	10	1113.0			10.0		
345	7	1220.0			5.4	1.6	
355	150	1336.0				150.0	
365	6	1457.0				6.0	
375	30	1587.0				30.0	
385	38	1725.0				38.0	
395	50	1869.0				50.0	
405	16	2023.0				16.0	
415	24	2183.0				24.0	
425	3	2354.0					3.0
435	1	2533.0					1.0
445	12	2720.0					12.0
455	10	2917.0					10.0
Total . .	869						
Total number of fish in each group			31	225	271	316	26
Sum of weight of eachgroup .			15308	152679	258057	502464	71405
Total weight			999913				

The number of fish belonging to each age group per a kilogram is calculated to give the following :

Age group	Number of fish per kilogm.
I	$0.001 \times 31 = 0.031$
II	$0.001 \times 225 = 0.225$
III	$0.001 \times 271 = 0.271$
IV	$0.001 \times 316 = 0.316$
V	$0.001 \times 26 = 0.026$

Thus in each kilogram weight of fish there were 0.031, 0.225, 0.271, 0.316 and 0.026 fish belonging to age groups, I, II, III, IV, and V respectively.

Following the same procedure to estimate the number of fish per kilogram and using empirical weights instead of the calculated figurs, table 8 is obtained .

Table 8 shows the relation between the age groups in number. Length frequency is transformed to weight frequency when the empirical weights were used. Thus, the weight of each age group was calculated which is shown in the following table :

Age group	I	II	III	IV	V	Total
Weight in gms . .	14705	159318	255873	493458	72700	996054
gms per kilogram	14.8	160.0	256.8	495.4	73.0	1000

The above table shows that the ratio of the weight of age groups I, II, III, IV and V were equivalent to 14.8, 160.0, 256.8. 495.4 and 73.0 respectively. That is in each kilogram weight of the catch of *Tilapia nilotica* there were about 14.8, 160.0, 256.8, 495.4 and 73.0 gms of age groups I, II, III, IV and V respectively.

TABLE 8.—AGE DISTRIBUTION OF *Tilapia nilotica* SHOWING THE RELATION BETWEEN THE AGE GROUPS IN NUMBER AND WEIGHT, WHEN THE EMPIRICAL WEIGHT IS USED.

Lenght in mm	Number	Weight	Number of fish in age groups				
			I	II	III	IV	V
255	43	446	17.2	25.8			
265	60	517	8.6	51.4			
275	22	588	4.4	17.6			
285	112	776		84.0	28.0		
295	9	762		3.6	5.4		
305	20	900		3.3	16.7		
315	43	870		0.0	43.0		
325	203	985		40.0	162.4		
335	10	1120			10.0		
345	7	1180			5.4	1.6	
355	150	1295				150.0	
365	6	1410				6.0	
375	30	1560				30.0	
385	38	1710				38.0	
395	50	1860				50.0	
405	16	2000				16.0	
415	24	2170				24.0	
425	3	2340					3.0
435	1	2600					1.0
445	12	2690					12.0
455	10	3080					10.0
Total . .	869						
Total number of fish in each group			31	225	271	316	26
Sum of weight of each group .			14705	159318	255873	493458	72700
Total weight			996054				

When these results were compared with the results obtained from the calculated weights no noitceable difference was observed. Thus, the validity of length-weight relationship is confirmed.

The study of age distribution of *Tilapia nilotica* shows that age group IV is the most important of the five age groups studied. Age group IV constitutes about 36% of the number of fish investigated. When the weight is studied, this group forms about 50% of the five age groups.

Age groups III and II are the second and third important age groups when both number and weight are considered. In spite of the fact that they constitute about 31% and 26% respectively of the catch by number, they become less important when the weight is considered. Thus, age group III forms about 26%, and age group II forms only about 15%of the catch.

Age group I does not form any significant percenatge of the catch when both the number and weight are considered. Age group V forms 3% of the number of fish caught which becomes more important when the weight is considered and forms 7% of the catch.

Survival rate

The survival rate of the investigated species of Nile fish has been studied from length frequency. In this chapter the survival rate will be studied from another source of data i.e. the age distribution or age composition. In fact the age distribution is governed by two factors i.e. recruitment and survival rate. Recruitment tends to increase the abundance or number of fish, while the survival rate or mortality rate decreases the stock. As far as fish populations or fish stocks are concerned recruitment together with growth represent the anabolic process in the physiology of an organism. The instantaneous mortality rate (which is the natural logarithm of survival rate with sign reversed) represents catabolism.

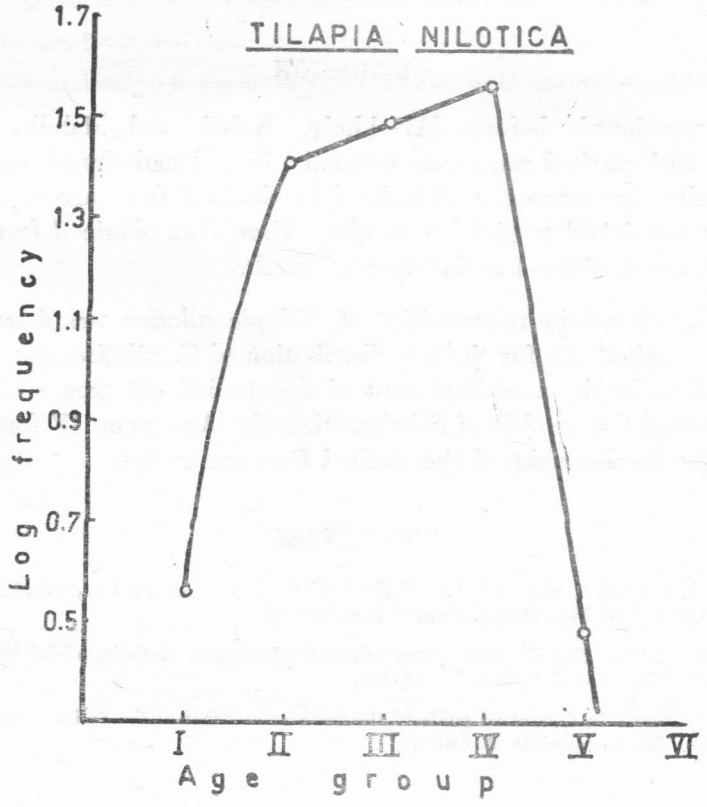
The instantaneous mortality rate is composed of two components viz instantaneous natural mortality and instantaneous fishing mortality. Estimates of the last two parameters from the instantaneous total mortality is of primary importance for fishery management. The survival rate as well as the instantaneous total mortality rate are going to be measured here from age composition as shown by Ricker (1958). Thus, the logarithms of number of fish of successive ages is plotted against the corresponding ages. This curve shows an ascending left limb and a dome representing age classes which are incompletely captured by the gear used for sampling. Then the third part of the catch curve is a straight line descending right limb. This part represents year classes which are captured in numbers proportional to their abundance in the water mass.

The straightness of the right limb indicates a unifrom surival with age (i.e. uniform fishing and natural mortality), no change in mortality with time, a random sampling and a uniform recruiment (Ricker, 1958).

Deviations from the straightness of the right limb are due to deviations from the conditions mentioned above. The instantaneous total mortality will be estimated according to the method described by Ricker (1958) i.e. estimating the slope of the straight line descending right limb of the catch curve, changing the sign and multiplying by 2.303.

The following table shows log frequency of the different age groups of *Tilapia nilotica* .

Age group	I	II	III	V	V
Percentage . . .	3.6	25.9	31.2	36.3	3.0
Log_{10} percentage .	0.5563	1.4133	1.4942	1.5599	0.4771



The catch curve was plotted as seen in Fig. 4. It shows an increasing left limb from age I - IV. Age IV acts as the done of the curve. From age IV - V the catch curve takes the from of a straight line decreasing right limb.

The slope of the straight line

$$= \frac{1.55 - 0.47}{4 - 5}$$
$$= -1.08$$

Instantaneous total mortality

$$= -1.08 \times -2.303$$
$$i = 2.487$$
$$S = e^{-2.487}$$
$$= 0.083$$

Due to the fact that the survival rate studied by means of this method gave a very low result, mortallity and the survival rates given by means of the length frequency were considered as the accepted results.

DISCUSSION

As mentioned before (Al kholy, Rafail and Mahdi ; 1973 a) mortality and survival rates were estimated from length frequency. When these results were compared with the data obtained from age composition, the latter was found to give low results. Thus, data obtained from length frequency are considered as the accepted results.

The length-weight relationship of *Tilopia nilotica* was described by a single equatios. As for the age distribution of *T. nilotica*, age gtoup IV was found to be the most important of the studied age groups. It Forms about 36°/0 of the number of fish investigated. Age group IV forms about 50% of the total weight of the studied five age groups.

REFERENCES

ALKHOLY, A.A. ; S.Z. ROFAIL and M.A. MAHDI 1973 a.—Biological Studies on Sudanese inand fishes I. Bull Inst. Ocean. Fish. A.R.E. vol. III.

RICKER, W.E 1958·—Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 119 : 1-300.

SANDON, H. 1950.—In illustrated guide to the freshwater fishes of the Sudan. Sudan Notes Rec., Mc Corquodale & Co.